The results he obtained were not great, but were sufficient to enable him to announce that a magneto-electric machine could be constructed which would have the advantage of giving the induced currents all in the same direction, without the help of mechanical arrangements to separate opposed currents or to make them conspire with one another.

From the foregoing analysis of Pacinotti's memoir, there can be no doubt that it contains a description of the ring armature which in the hands of Gramme has recently led to the construction of magneto-electric machines giving continuous currents of great intensity. I cannot, however, pass over without notice an extraordinary blunder into which Pacinotti has fallen, and which would render any machine constructed after his model altogether valueless. By a reference to Fig. 2, which, as well as Figs. 1 and 3, has been engraved from a photograph of the plate appended to the original memoir, it will be seen that the letters N and S are placed at the end of the diameter of the ring which is at right angles to the line A B joining the poles of the fixed magnet. That Pacinotti intended these letters to designate north and south magnetic poles is manifest from the following passage among others in his memoir :—" Osserviamo che per influenza sulla elettro-calamita mobile si formano i poli opposti alle estremità di un diametro in presenza ai poli della calamita fissa. *Questi poli* N S mantengono una posizione fissa anche quando la elettro-calamita trasversale ruota sul suo asse." It is hardly necessary to say that the positions assigned by Pacinotti for the poles in an iron ring under the influence of a fixed magnet are in reality those of the neutral points, or points of no magnetism, and that the magnetic poles of the ring are at a distance of 90° from the positions stated by him. This mistake has led to a serious blunder in the construction of his machine, the metallic rollers which carry off the induced currents being placed, not at the neutral points (as Pacinotti has himself clearly showed that they ought to be), but at the poles of the ring. That any effects at all were obtained from the model at Pisa, we must attribute to the slight shifting of the poles of the ring due to its rotation. Apart, however, from this unaccountable error, it can scarcely be disputed that to Pacinotti is due the merit not only of having devised the ring armature or transversal electro-magnet, but of having also accurately analysed its mode of action.

(*To be continued.*)

LECTURES AT THE ZOOLOGICAL GARDENS*

V.

Mr. Garrod on Camels and Llamas

THE Tylopoda form a group which includes the Camels together with the Llamas ; the name indicating that their feet are covered with callous skin instead of with hoofs as in the typical Ruminants, from which group they also differ considerably in many other characters, to be considered seriatim.

Horns are not developed in either sex. The upper lip is hairy and partly cleft. False hoofs are wanting. The general body-proportions are not so symmetrical as in any of the Cavicornia or Deer. Osteologically several special features present themselves. In the vertebræ of the neck the canals which are developed in the transverse processes, for the vertebral arteries to run in on their way to the brain, are excavated in the sides of the spinal canal of the cervical region. In the ankle two of the bones—the naviculare, or scaphoid, and the cuboid—which are anchylosed in the true Ruminants, are independent of one another. In the upper jaw there are two teeth developed, one on the side of each premaxilla; they are therefore lateral incisors. The canines in the lower jaw are of a different shape, and are separated by an interval from the incisors. The molars form a series of five above and four below ; in the Camels, but not in the Llamas, an additional small premolar, isolated in position and following the canine, is to be found in both jaws, increasing the grinder series to six above and five below on each side.

The abnormal conformation of the gastric section of the alimentary canal in the Camels has attracted the attention of many naturalists. In the Llamas the same structure maintains. As in the typical Ruminants the stomach is composed of several cavities communicating one with the other, but there is some difficulty in deciding which are the exact homologues of the *rumen*, *reticulum*, *psalterium*, and *abomasum*. The first cavity is a capacious globose sac into which the œsophagus opens. A longitudinal band of muscular fibre partly constricts it, in its course from the right side of the cardiac orifice backwards along the ventral surface, opposite the middle of which a narrow and long aggregation of "water cells" starts to continue tranversely towards the left side of the organ. This longitudinal muscular band forms one of the boundaries—the left one—of a much larger collection of deeper water cells, which embrace the posterior portion of the right side of the paunch in the concavity of their crescentic mass. From the right of this first main compartment a second smaller one is cut off by a constriction which leaves a considerable opening between the two. Its position is that of the reticulum ; it is deeply honeycombed, the lining membrane of the cells being covered with villi much like those on the surface of the folds of the psalterium of the deer, &c. The cell-walls are thin and but slightly muscular. In the paunch the mucous membrane is smooth and not at all thick. The water-cells are formed on a framework of many intersecting muscular sheets arranged in layers with intervals of less than an inch between them, one half being at right angles to the other, so as to form rows of quadrilateral cavities. These are again incompletely divided up by secondary septa. The orifices of the cells are partly closed by diaphragm-like membranes at their mouths. Most probably the contraction of the aggregated muscular fibres in the same situations is capable of closing the cells completely when necessary. That the camel can store fluid in these water-cells is borne out by the experience of so many authors that doubt is scarcely possible. For instance, in his "Travels to discover the Source of the Nile," Bruce (vol. iv. p. 596) tells us on one occasion that "finding the camels would not rise, we killed two of them . . . and from the stomach of each got about four gallons of water, which the Bischareen Arab managed with great dexterity." As John Hunter remarks, there is no physiological reason why this should not be the case. A specialised structure is observed by zoologists ; a special power is attributed by travellers ; the function and the structure may be reasonably correlated: why should they not be so, as no other explanation suggests itself? There is no arrangement for closing the cells of the reticulum similar to that found in those of the rumen.

A muscular fold runs from the termination of the œsophagus along the superior or vertebral side of the lesser curvature of the stomach to the third compartment, which evidently directs the products of rumination into it, just as the two folds of the same region do which traverse the reticulum in the typical Peccora. Following the honeycomb-bag is a single elongate cylindrical cavity, which dilates slightly and becomes bent at its pyloric extremity. This compartment is thin-walled and longitudinally ribbed internally for its proximal five-sixths, beyond which the mucous membrane is much thickened and evidently digestive in character, especially in the neighbourhood of the angle of the inflection in that region. This section of the stomach apparently corresponds to

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* Continued from p. 69.

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the abomasum, the psalterium being absent. In the Bactrian Camel there is a partial constriction in it, which separates off a small proximal cavity, which may be its homologue.

In the corpuscles of the blood the Tylopoda are unique among Mammalia, these minute discs being oval instead of, as in all other members of the class, circular.

Of the Camels there are two species, both domesticated, the Bactrian and the Arabian; the one possessing two humps and the other one. A swift variety of the latter is called the Dromedary. The former inhabits Turkestan, Persia, Thibet, and Mongolia; the latter Arabia and Northern Africa. Of the Llamas there are two wild species which have each of them domesticated representatives; the feral Guanaco and Vicuna finding their tame representatives in the Llama and Alpaca. They are all found in the Cordilleras of the Andes, down as far as Terra del Fuego. Taking the Tylopoda as a whole, their geographic range is extremely exceptional. Closely allied animals, as the Ostrich and the Rhea, are found in South Africa and South America respectively. North Africa and Arabia, in some respects, resemble India, as far as their fauna is concerned. No similar ties bind Northern Africa with South America, and it is this which makes the distribution of the Camels and Llamas so abnormal and so inexplicable, on the assumption that they sprang from a common ancestor as far back as the Miocene age, when we take as our basis the assumption that the existing zoological regions are the remains of a very different distribution of land.

(*To be continued.*)

THE LINE BETWEEN HIGHLANDS AND LOWLANDS

THE usual ten days' excursion which terminates the work of the Geological Class at the University of Edinburgh, has this year been devoted to an experiment in the practical teaching of Geology which bids fair to be often and profitably repeated—viz., the working out of a definite problem in the field, teacher and students together. In the Class excursion to Arran in 1872, it was observed that the Old Red Sandstone appeared to be brought against the Highland schists by a fault. Last year the fault was actually seen by the Class on the other side of the island in the cliffs of Stonehaven. Accordingly, the task proposed to be accomplished this year was to trace this dislocation across the country, if possible, from sea to sea. Such a traverse would at least bring the pedestrians face to face with some of the finest and least visited river scenery in Scotland, while it would probably also impress some geological lessons on their memory in a way not likely ever to be forgotten. At the same time it might be successful in discovering some new points in British geology.

The party mustered at Edinburgh, and proceeded at once to Stonehaven, where the first day's work consisted in following the magnificent coast-section which rises above the sea in the picturesque cliffs of Kincardineshire. The fault by which the slates and greywackes of the Highlands have been brought side by side with the red sandstones and shales of the Lowlands was again found. The rocks have there been so greatly squeezed against each other that their line of separation is by no means so abrupt as it might be expected to be. Instead of the mass of débris which so often fills up the space between the cheeks of a large dislocation, there was in this case a somewhat tortuous line of junction along which, without any broken materials intervening, the two series of Highland and Lowland rocks seemed to be, as it were, welded together. One might pass this part of the section and fail to notice the fault, though at the distance of a few yards he would find himself in a totally different set of rocks, and would then turn back to discover the actual line of separation. That this fault must be an important one was first shown by the fact that the strata of the Old Red Sandstone have here been thrown on end for more than two miles back from their junction with the Highland rocks. Along the noble coast cliffs the beds of sandstone and conglomerate stand on edge like books on the shelves of a library. The portion of them so placed considerably exceeds 10,000 feet in thickness, and yet by no means includes all the Old Red Sandstone of this part of Scotland.

From Stonehaven the party worked its way across the country for more than 100 miles to the Aberfoyle district. The line of junction between the slates and the Old Red Conglomerates and Sandstones was traced at many points, and sometimes followed for miles across the moors. In no case was the actual fault again seen, but its position could be in most cases drawn firmly on the map by help of the numerous sections laid open by the rivers which descend from the south-eastern slopes of the Grampians. As the journey advanced, however, it was discovered that the fault did not always lie between the Highland rocks and the Old Red Sandstone, but that it sometimes left bays of the latter formation on its north side. This was a new and interesting fact, for it showed the base of the Old Red Sandstone of these regions lying undisturbed and unconformably upon the upturned edges of the slates. In these bays were found enormous beds of coarse volcanic conglomerate and sheets of porphyrite, precisely agreeing with those which form the chains of the Ochil and Sidlaw Hills on the south side of the great valley which here flanks the Highlands. It was, therefore, apparent that the lavas, ashes, and gravels originally extended quite up to and enveloped the base of the Highland mountains that bounded on the north the inland sea or lake in which the Old Red Sandstone was deposited.

But perhaps the question of most general interest elucidated by this excursion was the relation between lines of dislocation and lines of valley. The fault which begins on the east coast at Stonehaven and runs in a straight line across the country to Arran—a distance of 170 miles—is probably one of the greatest, if indeed it is not absolutely the greatest, in Britain. We do not yet know the amount of displacement which it has caused. But that it was accompanied by enormous movement of the earth's crust is sufficiently proved by the band of vertical strata, sometimes more than two miles broad, which runs along its southern border. Surely if the valleys and gorges of this country, as many writers still contend, have been caused by or are coincident with lines of subterranean fracture, such a grand line of fracture as this ought to be strikingly characterised by such surface features. Particular attention was devoted to this point during the excursion, and the result may be briefly given. Not a single main valley was found to run along the fault, while all the valleys and some of the deep gorges emerging from the Highlands run directly across it without deflection. In one case only was there an approach to a coincidence between the line of the fault and a glen, viz., in that of Glen Artney. But there the dislocation, instead of keeping the centre of the valley, was found to run far up on the northern side, the stream in the centre winding to and fro across the vertical strata of Old Red Sandstone. Along its whole course the fault is not more marked than on other lines where two series of rocks of different characters and modes of weathering come together. But not only does no long and broad valley or series of valleys mark the line of this fracture in its passage across the island; it passes athwart the channels of the North and South Esk, the Prosen, the Isla, the Ericht, the Tay, and the Forth, without in the least degree producing any waterfalls or transverse gorges. Moreover, it cuts across two of the best known lakes of

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